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THE RELATION OF CLIMATE TO THE GEOGRAPHIC DISTRIBUTION OF CROPS IN THE UNITED STATES

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A study of the agricultural statistics collected by the Bureau of the Census, Department of Commerce, and of data published from year to year by the United States Department of Agriculture, reveals the fact that the staple, and even minor, agricultural crops of this country have a marked tendency to geographic segregation. When the intensity of production of the various products is graphically illustrated on charts or maps, there is a decided tendency for the various crops to group themselves into certain more or less definite areas, the boundaries of which are often rather sharply drawn. We find also that when we group all crops together certain sections show a decided preponderance of production.

The principal physical factors that influence localization of crops are topography, character of soil, distance from market, and climate. In the United States climate is the most fundamental, unalterable, and important, not only in influencing the geographic distribution of the crops grown, but also in determining the suitability of the land for agricultural purposes in general.

Only about one half of the land area of the United States permits of profitable production of crops by ordinary farming methods, the other half being unsuited for this purpose principally by reason of roughness, infertile soil, or unfavorable climate. For the country as a whole, nearly 75 percent of the total land area was classified by the census of 1920 as being unimproved.[1] About one fifth of the total amount, principally in the western half of the country, is too hilly or rough for cultivation, which leaves a large proportion unimproved for other causes than mere roughness. Much the greater part of this is unavailable by reason of unfavorable climatic conditions, principally insufficient moisture, although a considerable amount is used for grazing purposes, or for non-intensive agriculture by the employment of special methods, such as dry farming practices. The portion of the unimproved area located in the eastern half of the United States is comprised principally of lands under forest and cut-over, which are potentially agricultural, in so far as climate is concerned, although some of it, especially in the Appalachian Mountain section, is so rough or infertile as to be suitable only for growing forest products. Most of this land is found in the northern portions of Michigan, Wisconsin, and Minnesota, and in the South from Virginia and the Carolinas to central Texas. Most of the unimproved land in the West is wholly unsuited for intensive agriculture, when unirrigated, owing to scanty moisture.

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[1] Forest land is at present classed as unimproved. When land is under forest management and producing crops of timber—as much of it probably will be in the not distant future—should not some other form of classification be used? Ed.

In a study of the relation of climate to agriculture two general divisions of the country are necessary. The first on a basis of moisture alone, and the other on that of temperature and rainfall combined, with the former dominating. In the first division we must consider agriculture in the composite—that is, from the standpoint of the general suitability of the land for growing crops of any kind, without the employment of special methods, such as so-called dry farming, or by artificially supplying moisture by irrigation. The second division is on a more concrete basis and subdivides the larger areas more or less specifically by crops, such as the corn belt, the cotton belt, and other similar groupings.

Moisture Requirement of Crops

The amount of moisture required by crops for their best development varies for different localities and for different crops. The minimum amount of rainfall required under favorable distribution is usually considered to be between 15 and 20 inches of annual precipitation. Several modifying influences must be taken into account, however, which have wide geographic variations. Among these are soil texture as affecting its moisture-retaining qualities, temperature conditions, and rate of evaporation.

Broadly speaking, the 15-inch annual isohyet may be considered as the limiting line of our moisture division in the more northern portion of the United States and the 20-inch isohyet in the Central and Southern States, which conforms roughly to about the 101st meridian. Thus in our general division the country may be divided into two parts, the meridian mentioned roughly forming the dividing line. The total value of all crops grown in the United States in 1919 was nearly 15 billion dollars, about 90 percent of which was produced east of this meridian.

In a study of the amount of rainfall usually received in its relation to agriculture, the question of loss of soil moisture by evaporation becomes of much importance, especially in regions where the available moisture supply borders on the minimum limit for the successful production of crops, such as the sections we have just considered where the annual precipitation is from 15 to 20 inches. The rate of this evaporation depends principally on the soil texture, temperature, wind movement, and the relative humidity of the atmosphere, while the amount of moisture present and the loss by transpiration of vegetation are also important factors. It becomes, therefore, a difficult matter to determine by direct observation the loss of soil moisture by evaporation, and no extensive data showing this loss directly are available; but evaporation from a free water surface gives some indication of the relative loss from the soil for different localities. The amount of evaporation over the Great Plains region shows a pronounced and progressive increase southward from the Canadian border. The agricultural significance of these facts, stated in terms of actual equivalent rainfall, can be determined only approximately; but some investigations have shown that from an agricultural standpoint 20 inches of annual rainfall in eastern North Dakota is equivalent to about 30 inches in southern Texas. The 20-inch line of average annual precipitation extends in a north and south direction through the Great Plains region, conforming roughly to the 100th meridian of West Longitude. This line in North Dakota passes through a region where we find successful production of wheat, oats, timothy, and other crops characteristic of the humid type of agriculture; but in Texas it passes through a country devoted largely to grazing and the growing of drought-resistant crops, such as kafir and milo. Throughout the western section of the country evaporation from a free-water surface is much greater than the rainfall. At Yuma, Arizona, the evaporation from May to August, inclusive, is about 40 inches, while the normal rainfall is less than one inch for the same period; it is about 10 inches greater in southern Texas than in North Dakota.

In addition to evaporation, the seasonal distribution of precipitation is of prime importance. Where the rainfall is comparatively light and varies in different seasons of the year, it is necessary that the more generous amounts occur at a time when temperature conditions are favorable for vegetative growth. With an annual precipitation of only 15 inches, other conditions must be very favorable for profitable agriculture by ordinary methods. There are important grain sections in the more Northwestern States which receive on the average less than 15 inches of precipitation. In fact, in some localities wheat is grown where the normal annual precipitation is only 9 or 10 inches; but in such cases special methods for conserving the soil moisture must be practiced. In the great spring wheat region of the Red River Valley of the North, however, the average annual precipitation is only about 20 inches, and ordinary farming methods obtain.

Even with 20 inches of rainfall annually, if the amounts were uniformly distributed throughout the year, moisture would be insufficient for the production of most of the staple crops grown in the United States. We find in the great wheat-producing Plains region heavy grain production where the annual amount of precipitation is comparatively small. This has been made possible only by the favorable seasonal distribution of rainfall. There are a number of distinctive types of precipitation in the United States, and in this particular area the rainfall is characterized by generous amounts in the late spring and summer months, at a time when the moisture can be best utilized by growing vegetation, and by very light fall and winter precipitation. Owing to this fortunate provision of nature our moisture division line extends much farther westward than it otherwise would; and to this is due, in a large measure, the reputation of our western Plains States as a great grain-producing section.

Over a belt extending from Nebraska and Kansas eastward to Kentucky and Ohio a census classification shows about 66 percent of the total land area as improved, while to the northward from 30 to 45 percent is so classified, and to the southward from 16 to 40 percent. For the States of Montana, Idaho, Wyoming, Nevada, Utah, Arizona, and New Mexico the classification shows an average of only about 3 percent of the total as improved. While the topography of the latter area precludes a high percentage of improved land, deficient moisture is largely responsible for the very small percentage shown there, and ample moisture for the high percentages farther east.

From the standpoint of rainfall the United States is one of the most favored countries of the world. The vast expanse of comparatively level and fertile land extending from the Rocky Mountains on the west to the Atlantic Ocean on the east, and from the Great Lakes to the Gulf of Mexico, receives, as a rule, adequate moisture, and temperature conditions are mostly favorable for intensive agriculture. There are from time to time, it is true, rather severe and damaging droughts, and occasionally there is too much rain; but when either of these conditions obtains, the area affected is usually more or less localized, leaving sufficiently large favored sections to supply the nation with needful food, and some to spare; no famine specter thus far has ever disturbed us. However, there are large areas in our Western States comparatively unproductive that would greatly increase our agricultural output were sufficient moisture available. It has been estimated that about 30,000,000 acres of this semi-arid land is potentially irrigable, were all available sources of water supply fully utilized for irrigation purposes. This would provide over 300,000 additional farms. As the initial cost of developing irrigation systems increases with development of less favorable projects, the work will probably proceed rather slowly. At the same time large areas of relatively unproductive land in our Eastern States where climatic conditions are favorable are susceptible of improvement at a comparatively small expense, with the added advantage of being nearer the principal market centers.

Temperature Influence on Crop Distribution

In studying the geographic distribution of specific crops, temperature conditions are found to have a greater influence than rainfall. In this case we shall consider only that section of the country east of the Rocky Mountains, or the principal agricultural area, in which precipitation is usually sufficient. The average summer temperature and the average winter temperature, especially the former, have a more direct bearing on crop distribution than that for the other seasons of the year. The agricultural provinces have more or less definite boundaries extending, in a general way, in an east-west direction conforming to the isothermal trend. A definite amount of heat is required to bring a crop to maturity. A rough measure of this may be obtained by temperature summation or what is known as the "thermal constant." This is the total, or accumulated, day-degrees of temperature in excess of some significant temperature taken as a starting point, computed to the date of maturity. The thermal constant of a particular plant and the temperature at which its growth may be started determines whether or not the temperature conditions in a given locality are favorable for its maturity. The planting of a given spring crop usually begins in the southern portion of the area in which it is grown and proceeds northward as the season progresses. There are certain restricted limits of time within which crops must be planted for best results, defined by the temperature conditions of the locality, and this period of time decreases in general with increased latitude. The planting and harvesting dates for the staple crops of the United States have been determined by the U. S. Department of Agriculture.[2] A study of these reports in conjunction with normal temperature conditions brings out some interesting facts. While the normal daily temperature at which planting usually begins differs for different plants, it is quite uniform for the same plant throughout the country. The seeding of spring wheat begins when the normal daily temperature rises to about 37° F., spring oats at 43°, early potatoes at 45°, corn at 55°, and cotton at 62°. Whether a farmer lives in the South or in the North, he has, unknowingly no doubt, adopted these temperatures as the proper ones at which planting should begin. Thus the planting of early potatoes, for example, usually begins in northern Mississippi about February 15, and in northern Wisconsin two and one half months later, but in each locality when the normal daily temperature rises to 45° F.

In a general way, we may divide crops into two classes, those known as cool-climate crops, more intensively grown in the central and northern sections of the country, and warm-climate crops, grown chiefly in the Central and Southern States. Among the former may be included potatoes, wheat, oats, buckwheat, flax, and most grasses; among the latter we find cotton, corn, rice, sugar-cane, and peanuts. While the most intensive production of both winter wheat and corn is found in the same area, one classed as a cool- and the other as a warm-climate crop, the former matures early in the season before the warmer weather of summer comes, while the most critical period of growth of the latter is the warm mid-summer season.

As an illustration of the grouping of certain crops in more or less limited areas, it may be pointed out that about one half of the corn produced in this country in 1919 was grown in 6 States: Ohio, Indiana, Illinois, Iowa, Missouri, and Nebraska. If to these we add 5 others, namely, Minnesota, the Dakotas, Kansas, and Oklahoma, we include an area that produced more than

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[2] Baker, O. E., Brooks, C. F. and Hainsworth, R. G., "A Graphic Summary of Seasonal Work on Farm Crops," Yearbook, U. S. Department of Agriculture, 1917.

70 percent of all the wheat and oats grown in that year. More than 70 percent of the white potatoes were produced in the Middle and North Atlantic and North Central States, and more than 90 percent of the sweet potatoes and practically all of the peanuts in the South. On the other hand, about 95 percent of the flax area is found in the Dakotas, Minnesota, and Montana, while more than three fourths of the buckwheat acreage is found in New York, Pennsylvania, and Michigan. Practically no cotton is grown outside the principal cotton belt, and four fifths of the domestic rice comes from Louisiana and Texas.

In a general survey of that portion of the country lying east of the Rocky Mountains, we find 5 more or less distinctive climatic provinces, which correspond to definite crop groupings. These may be designated the sub-tropical coast, the cotton belt, the corn and winter wheat region, the spring wheat belt, and the hay and pasture province.

Sub-tropical Coast. This section has a warm and comparatively equable climate, with an average winter temperature ranging from about 55° F. along the central Gulf coast to 70° in extreme southern Florida, and an average summer temperature of 80° to 82°. The principal crops in this province are winter truck, citrus fruits, sugar-cane, and rice. The winters are usually mild, although an occasional cold wave may be experienced; temperatures as low as zero have been recorded to the Alabama coast. The summer temperatures are appreciably tempered by proximity to the Gulf.

Cotton Belt. The northern limit of successful commercial production of cotton is determined almost entirely by temperature conditions. A mean summer temperature of about 77° F. is the limiting value, which corresponds to a frostless season of about 200 days. Along the northern margin of the belt the last killing frost in spring occurs on the average about April 10, and the first in fall about October 25. The mean summer temperature in the southern portion is about 82° F. The cotton plant grows successfully under a much wider range of precipitation than of temperature. In the cotton-growing States the average annual rainfall varies from little more than 20 inches in the extreme western portion to 55 or 60 inches in some eastern sections of the belt. Cotton is unfavorably affected by too much moisture perhaps as often, or more so, than from insufficient precipitation. May and June particularly are critical months, when cool, wet weather is detrimental. The thermal constant for cotton, computed from the normal daily temperature at the average date of planting to the beginning of picking, is about 1,900° F., compared with about 1,600° for corn in central Iowa and 1,800° in central Ohio. The difference in heat requirement of the two plants is greater, however, than these figures would seem to indicate. For it must be remembered that these computations are made on the basis of the beginning of cotton picking, while as a matter of fact, unlike corn, the ripening season continues long after the first bolls are open, and, for commercial success in production, temperatures must continue sufficiently high for some time thereafter to bring to maturity the late formed bolls. In addition, corn planting usually begins with a mean daily temperature of 55°, while cotton requires about 62° for proper germination, which means, in time, the better part of a month. Cotton forms about 60 percent of all crops grown in this belt.

Corn and Winter Wheat Belt. The principal corn and winter wheat belt extends roughly from the Ohio Valley States westward to the Rocky Mountains. The average winter temperature in this area ranges from about 40° F. in the southern portion to 15° in the northern, and the average summer temperature from about 78° in the south to 70° in the north. The average frostless season ranges from about 140 days in the north to about 200 in the south. The thermal constant for corn in the principal producing areas ranges from 1,600° to 1,800° F., computed as previously indicated. Along the northern limit of successful commercial production it is about 1,400°, but in some southern States, where slower maturing varieties are planted, it runs as high as 2,800°. It is interesting to note that in the more southern States there is a large excess of heat during the growing season over that required for maturing corn. For example, in southern Georgia the potential thermal constant for this crop, when computed from the accumulated day-degrees of temperature above the average at the time of beginning of planting to the average date of first killing frost in the fall, is over 4,000° as against 1,600° in central Iowa. This permits of successive plantings in the south covering a considerably longer period in the spring. That is to say, early, intermediate, and late crops can be grown.

Spring Wheat Belt. This belt lies mostly in the north-central section of the country, principally in the States of Minnesota, the Dakotas, and Montana. The average summer temperature along the Canadian border is about 65° F., while the southern boundary of the belt conforms approximately to the mean summer isotherm of 70°. This is by no means the northern limit of spring wheat production, however, as much is grown in the Canadian provinces farther north. In the United States the average frostless season of the belt varies from about 100 days in the north to about 140 days in the south. As in the corn and winter wheat belt, farming is rather diversified, but spring wheat forms more than one third of the crop acreage.

Hay and Pasture Region. This province is less well defined than the others mentioned and is, as a rule, a region of varied agricultural conditions. It includes mostly the northern border States from Minnesota eastward and extends to the Middle Atlantic States and Appalachian Mountain districts. The average summer temperature ranges from about 62° to 70° F., and the average winter temperature from 10° to 25° F. Climatic conditions in this province are favorable for the production of potatoes, buckwheat, and other cool-climate crops, but the dairy products predominate. They amount to about one half of the total for the United States.